CHAPTER 1

INTRODUCTION

1.1 Background

Many resources such as water, material and energy are consume by building such as office, residential and shopping complex. According to Eiker (2009) the world's main energy consumption is by building and it contributed to one third of global CO_2 emission. Meanwhile air-conditioning is the main component that contribute to the energy consumption.

Over the year, observation has been done and it shown that there is increasing atmospheric concentration of greenhouse gases such as carbon dioxide, nitrogen oxide, sulphur dioxide and carbon monoxide give a bad effect to the atmosphere (Proops, et al., 1993). High concentration of carbon dioxide in the air cause the global warming which also contribute to climate change.

Nowadays, the climate change has affected the increase in temperature and people in Malaysia tend to use air-conditioning in their house either day or night. Since the air conditioners are working hard all over the country, the temperature is getting triple digits. Then they also release extra carbon into the air that cause global warming.

Analysis had been done and it shows that the cycle will be worst. Apart from that, a study strongly proposes that the rise is due to increase of amount of CO_2 and other greenhouse gases emission by the burning of fossil fuels. If these phenomena continuously happened, scientists expect the pattern will continue and in future can see more severe climate such as extreme heat in the upcoming day.

According to the Energy Commission (2010) in Malaysia showed that the need of electricity raise from 14, 245 MW in 2009 to 15, 072 MW in 2010 and goes up until 15, 476 MW in 2011. 20% of the energy source is being used by domestic sector. To generated power for air-conditioning consumes 21% of this apportion and 2% to control other mechanical fans (IEA, 2009).

Apart from that, Chan (2004) state that in year 1999 there are 493,082 unit of air-conditioning used in residential building owned by people in Malaysia. Then it was rise up by 6.7% which is 528,791 units in year 2000 and rapidly increases by 42% (907,670 units) in 2009 (Saidur et al., 2007). Uncomfortable environment tend people to turn on air conditioner in their house and this cause the emission of the CO2 in the atmosphere getting serious. 75% of people in Malaysia depend on air conditioning in order to keep themselves in comfortable surroundings (Al Yacouby et al., 2011).

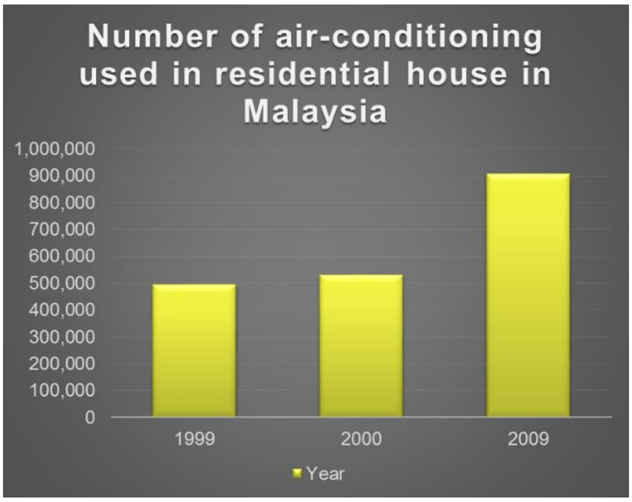

FIGURE 1.1 Number of Air-Conditiong used in residential house in Malaysia

1.2 Problem Statement

Nowadays Malaysian construction industry sector such as development of residential house, high rise building, bridge tunnel and factory had growth rapidly. This industry growth has given good impact to our country but there is also a bad site that give impact to our mother nature.

Today all over the world known and well acknowledged that climate change induced by the emission of greenhouse as one of the most significant global environmental problem facing the world and it can give effect to the human welfare and our ecosystems. Climate change is expected to give a worst effects on energy requirement for building as it need for cooling and heating when dealing with highly temperature and other weather.

Global warming is predicted to have resilient effects on future energy demand of building especially regarding the heat aspect. Hence the implication through climate change is the electric demand increase and it cut the energy resource reliability. Also with the increase in new construction industry especially construction of new building and ineffective consumption energy consumption in the present building, the yearly energy consumption is estimated to be more.

According to IPCC Second Assessment Record (1995) emission of carbon dioxide increase into the atmosphere cause the global climate change and it is effect by human. Then, Kwok and Rajkovich (2010) stated that in the United State (U.S.), about 40% of the total energy required is consumed by building and in fact 34.8% of that is used for Heating, ventilation and air conditioning (HVAC) system.

Until now, the temperature is continuously increase and the cooling of natural ventilation would-be decreased. For example, during summer the request and needed for space cooling has decreased. The reason because of the increase internal temperature effluent by heat waves during that time. Indeed, based on study carried by Giannakopoulos and Psiloglou (2004) in Athens, Greece showed that the energy consumption in 2080s will increase by 30% during July and August. On the other hand, the average outdoor temperature has a strong relationship in between people’s comfort in building or house (Humphreys, 1978).

Due to climate change, many residential tend to use air-condition in their house to make sure the environment and temperature inside their house is comfortable. Carbon dioxide emission in air-condition is one of the major gases cause the green house and with this situation, the global warming become more serious.

Study have shown that heat transfer from the roof is one of the major cause to the house temperature. This requires current and future residential roof need to make and possible to perform better under changing climatic condition. Therefore, this research will identified the best residential roof when dealing with the weather change. The aim of this research is to investigate the weather change and the energy consumption in the residential house.

1.3 Research Objective

In order to meet the aim mentioned above, the research objectives are as follow:

- To determine the effect different type of roof on heat transfer into residential house.
- To determine the effect weather change to the energy consumption.
- To analyse the production of CO_2 in residential building.

1.4 Scope of Study

The duration for this project is about 32 weeks. This research focused on the different type of roof for residential house in a few location. Simulation will be done by using Energy plus Software and Design Builder to make a comparison in between the type of roof and its effect to the temperature inside the house. Based on the simulation, analysis will be done to analyse the energy consumption in residential building since it contribute to the global CO_2 emission.

CHAPTER 2

LITERATURE REVIEW

2 INTRODUCTION

This chapter covers the basis information about residential roof which covers the concept of roof framing system, insulator roof and its component. It is also cover the HVAC system design and later the input data will be insert during the simulation. Finally, a critical review is done to analyse and summarize this study of design and analysis of residential house roof using the Energy Plus software.

2.1 Residential Roof

Roof is one of the main important structures in the house or a building to cover and protect from weather, animals, especially rain, but also heat, sunlight and wind. The purpose of the building will determine the type of a roof that will shelter it. There are many type of roof for residential house such as cool roof, reflective roof, clay roofing tiles, concrete tiles and green roof.

Different type of roof will have different roofing system and the performance also will be slightly different. Selection of building construction materials also depends on the type of roof and the reason it being built. In most nations a roof protects primarily against rain and sunny day. There are many type of roof style. Figure 2.1 show the different type of roof system that can be used for roof construction.

Roofing system can reduce the energy consumption in residential house especially a house that using an air conditioning. Previous research have been done to investigate how roofing system impact air conditioning electrical demand. Choosing a suitable roof material will help a house owner to increase comfort and reduce the energy consumption.

According to Man (1976), even though there are many other factor that effect the indoor thermal atmosphere such as the climatic condition, type of material for the building and area of opaque but roof has the maximum temperature fluctuations. Roof will be more affected than other part of the building with the impact of the heat loss in the ultraviolet during the night-time and rain.

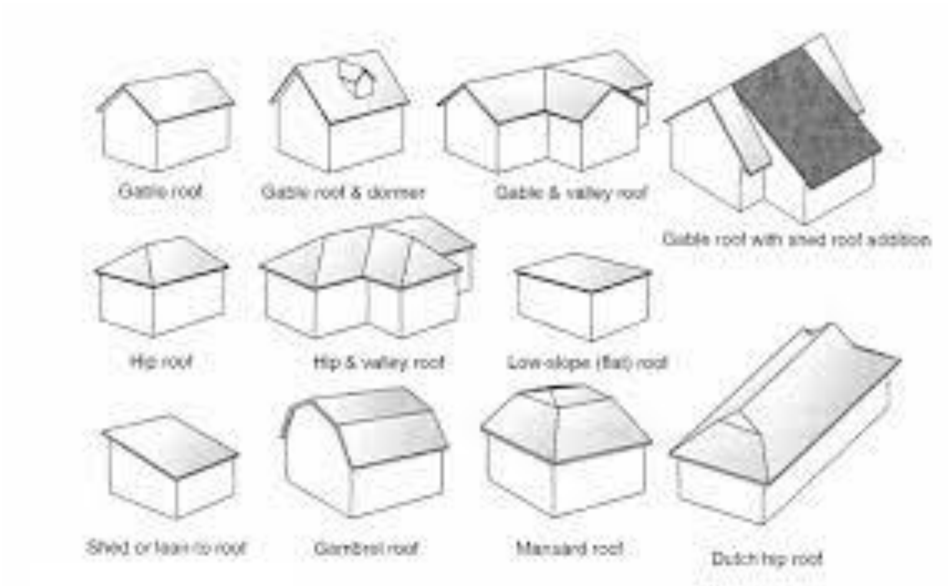

FIGURE 2.1 Common roof style (Source: google image)

As mentioned by Nahar et al (2003), in a hot climate 50% of the thermal load for building was cause by a roof where as Vijaykumar et al. (2007) showed that the roofing system represents 70% of the total heat increase. Based on this study shows that roof is the main part or component in the thermal performance of buildings.

Apart from that, Ginovi (1994) mention that colour can effected the temperature of the house. By using a light colour such as white can reduce the effect. The amount of heat absorbed is also affected by how light or dark an object is. A dark object of a given colour will absorb more photons than a light object of the same colour, so it will absorb more heat and get warmer. 40% reduction of cooling energy load was reported compared to 10% increasing in heating demand.

Based on Rosenfeld et al. (1995), he find out 40% of electricity consumption was save in a house in Sacramento, California (USA). The roof and wall of this house was painted in white colour. According to Urban and Roth (2010), it is showed that during hot days, the temperature of normal dark roof reach 66°C or higher than that but by using reflective roof under the same condition maintains its temperature about 28°C.

Allen et al. (2008) studied roof materials used in Malaysian communities: in terrace apartments (clay tiles 2.5%and concrete tiles 45%), bungalows (metal deck 5%, concrete tiles 17.5%, and clay tiles 5%) and in semi-detached houses (clay tiles 2.5% and concrete tiles 20%) and these supplies permit the high conduction of solar radiation that tempts a sauna effect, which creates an uncomfortable environment is one of the example of this situation.

Akbari et al., 2006 showed that the design of reflective roof is reduce the effect of the heat gain on building roots during sunny day. By using a cool roof system can reduce the energy consumption and reduce the trapped heat in the atmosphere by reflecting solar rays back into the sky which can delay climate change.

2.2 Flat Insulator Roof

The decrease or reduction of heat transmission in between an object to thermal contact is knows as thermal insulation. Thermal insulation can efficiently slowly the process of heat transfer in the thermal object. To slow down the heat transfer process, a low coefficient of thermal conductivity is need and in the most cases, most of insulating value approximately proportional to the thickness of materials.

During a hot day, month or even year, roof insulator can reduces solar thermal gain. There are many type of insulating material such as glass wool, sheep wool, high density slab and multilayer quilted foil system. There are two basic category of roof design in the insulation which are warm roofs and cold roofs.

The insulation above the structural deck kept the warm in the warm roof and a cold roof has the insulation that located below the structural deck which remain cold. The purpose of roof insulation are to preserve or slow down cooling and heating energy, to improve thermal comfort of the building and to decrease thermal expansion and contraction of the roof deck and structural framing.

FIGURE 2.2: Example of flat roof

M. Santamouris (2012) mention that the strategy of cool roof as main subject of the scientific community and market due to the operative and its effective in reducing the energy consumption, electricity demands and modifying urban heat island effects. In his research also said that cool roof or insulator roof consists of a system with coating by high thermal emissivity and high solar reflectance.

According to Kolokotsa et al (2012), due to insulator roof save about 19.8% of the energy conservation. Based on simulation results showed that about 1.5-2 °C indoor air temperature was reduce during summer and about 0.5 °C in winter. Other than that, Simpson and McPherson (1997) was conduct a study in Tucson, Arizona (USA). For the study purpose, they rescale the building with 1/4-scale model buildings and found out that white roof was cooler 20K compared to silver or grey roof and 30K cooler than brown roofs.

In addition, they estimated that the reduction of energy by air-conditioning are 5% for the white-coloured roof compare to the other house with roof-cooler with silver and grey. An air-conditioning energy reduce 19% after apply the high-reflectivity coating based on the research study for nine occupied house in Florida (USA) by Parker and Barkaszi (1997).

2.3 Energy Consumption

One of the main cause of climate change all over the world is by increasing the energy efficiency of the building (IEA, 2008). In fact, 30 to 40% of the international energy requirements is procedure by building energy, Houvila et al. (2007). In many studies found that energy consumption by residential house is one of the largest source energy demand and GHG production of domestic.

At the same time, D.Q at el. (2007) state that in urbanised and developing a nation, building and construction are responsible for approximately 30% of global greenhouse emission and 40% of energy consumption. Similarly study also prove that carbon dioxide emission and the environmental consequences is the main element in the emission situations that need to be consider in energy consumption of a building.

Apart from that, the emission of carbon dioxide by building is estimated around 8.6 million metric tons in 2004. The meaning of carbon emission is the carbon dioxide emitted right or incidentally by activity. Carbon dioxide is emitted from using of an air-conditioning, combustion of fossil fuels for cooling, heating and other purpose. Then, D.Q at el. (2007) state it was estimated that one third of total greenhouse gas releases connected to carbon dioxide and 60% of halocarbon emissions in year 2004.

He also mention the energy consumption and energy emissions by commercial house are anticipated to increase by 2.5% per year. Meanwhile according to Kwok and Rajkowich (2010) and Zhou et al. (2008) building such as residential house accountable to considerable proportion of energy-related emissions.

Based on previous study Yu et al. (2008) investigate a few design envelope strategies to reduce the energy by air-conditioning during winter and summer in Changsha, China. Similarly to Feng and Jun (2013) was examine the energy consumption of tall building with different climates in chine with the effect of reflective material. The study shows that, the cooling energy decrease about 7 to 15% whereas the heating energy goes up from 4 to 23%.

CHAPTER 3

METHODOLOGY

3 INTRODUCTION

Data collection is one of the most important step to success this research. In this chapter, the procedure of getting the data will be describe which from the step of deciding the research strategy, research method and until the step of doing Data analysis.

3.1 Project Flow Chart

In order to make sure this project run smoothly, below is the project flow chart.

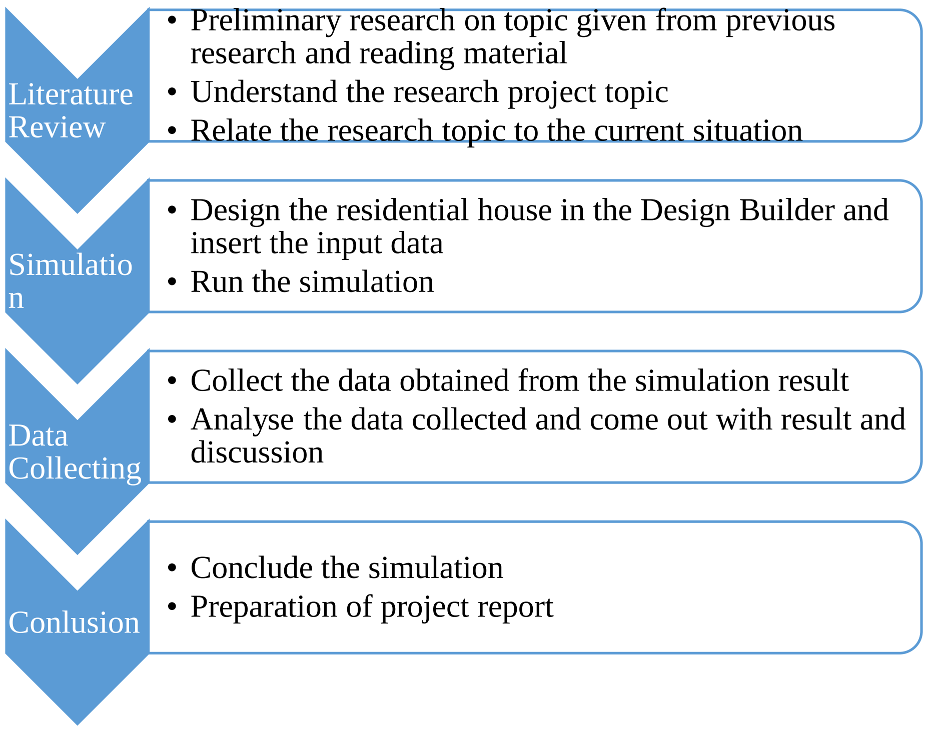

FIGURE 3.1: Process Flowchart

3.2 Key Milestone

3.2.1 Key Milestone for Final Year Project I & II

Figure below show key milestone during final year project I and II. The duration is 28 week. In order to make the project run accordingly, author had set the key milestone that need to be achieve during the time.

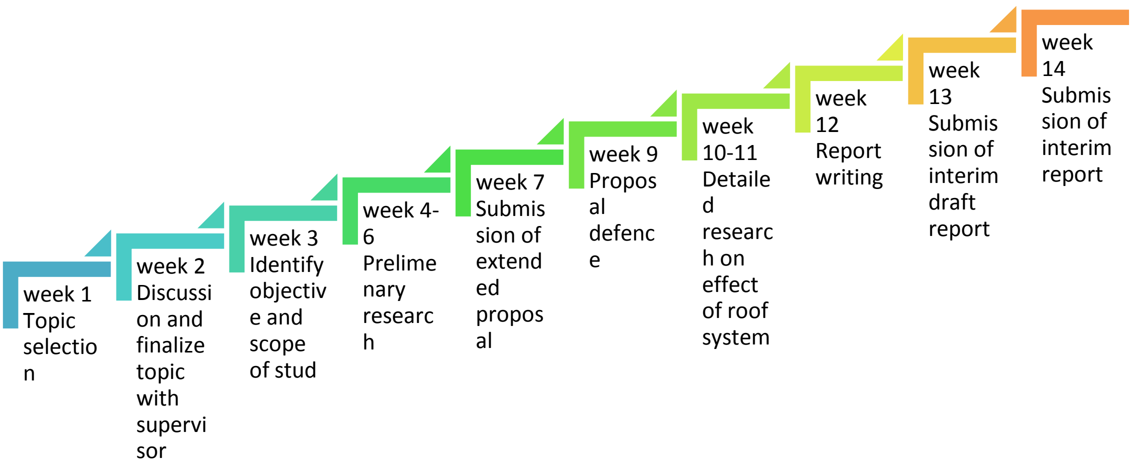

FIGURE 3.2: Key Milestone for Final Year Project I

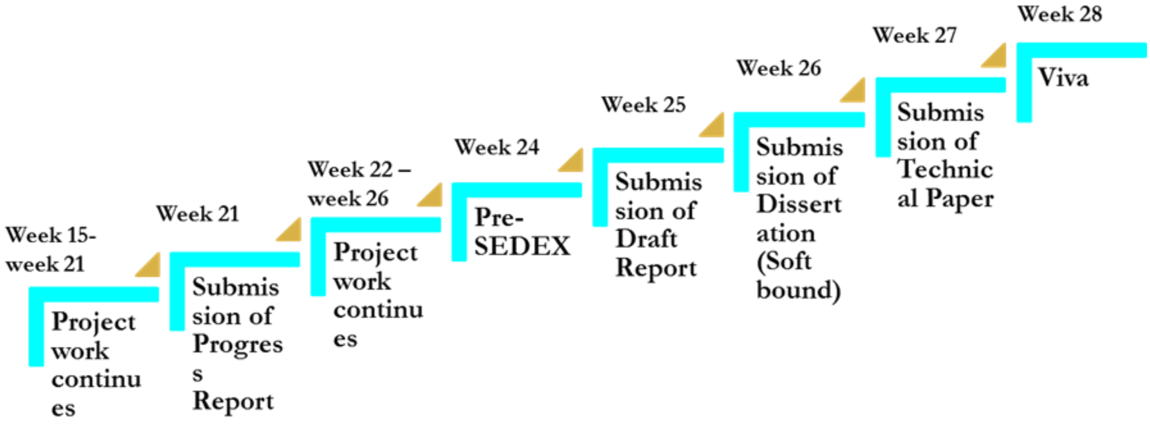

FIGURE 3.3: Key Milestone for Final Year Project II

3.2.2 Key Milestone for Final Year Project

Selection of project topic	(14/1/2015)
Preliminary research work	(26/1/2015)
Submission of extended proposal	(18/2/2015)
Proposal defence	(25/3/2015)
Project work continue	(09/4/2014)
Submission of interim report	(17/4/2015)
Project work continue	(03/7/2015)
Submission of progress report	(06/7/2015)
Pre-Sedex	(22/7/2015)
Submission of Dissertation (soft bound)	(08/8/2015)
Submission of Technical Paper	(14/8/2015)
Viva	(18/8/2015)

FIGURE 3.4: Key Milestone for Final Year Project

3.3 Gantt Chart

Gantt chart below is the planned schedule for Final Year Project II.

Description of work	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Research on energy consumption	/														
Survey on roof system use in residential house in Malaysia		/													
Critical analysis on the survey			/												
Summarize the data				/											
Comparison on the roof cost and it efficiency					/										
Analyse result obtained and discussion						/	/								
Submission of Progress Report								/							
Design the residential roof system using BIM									/						
Proposed a suitable residential roof for Malaysia climate										/					
Pre-Sedex											/				
Submission of Draft Report												/			
Submission of technical paper and dissertation													/		
Oral Presentation														/	
Submission of hard bound dissertation															/

FIGURE 3.5: Gantt Chart

3.4 DesignBuilder Software

FIGURE 3.6: DesignBuilder Software

DesignBuilder software is a modelling tools in a simple and easy way to use. It enables for all designer and their team to use the same software for developing comfortable and sustainable building design beginning with the design concept until the completion of the project. A version of DesignBuilder used in this simulation as per below:

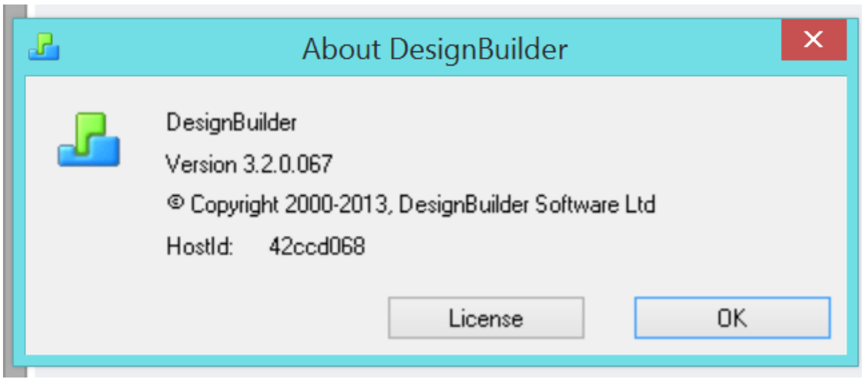

FIGURE 3.7: DesignBuilder Version 3.2.0.067

DesignBuilder offers a series of environmental performance data such as carbon emission, HVAC component sizes, energy consumption, maximum summertime and comfort condition. In this project, DesignBuilder were used to:

- Calculating building energy consumption.
- Calculating the production of CO_2
- Calculating heat gain by roof
- Design a double story house

3.5 Energy Plus Software And Analysis

Energy Plus software tools commonly used in building simulation that related to energy. It is fully integrated structure; ventilation, heating system, and air conditioning (HVAC); and renewables simulation program is one of the most robust simulation tools available in the world today. By using Energy Plus, a simulation on cooling, lighting, ventilating energy flows and building heating can be done.

Since the software is mainly used for thermal load and energy analysis simulation, many program can be includes in Energy Plus such as modular systems, plant integrated with heat balance based zone simulation, multi-zone air flor and natural ventilation. For simulation purpose, weather files can be download in a text file format. The weather data file consist of many different place and location around the world (See Appendix A for example file).

To run the simulation, Energy Plus needs other software or programs to provide a input data such as graphical drawing. For this project purpose, Design Builder Software was used to provide a drawing and model for the simulation purpose. All the parameter and analysis can be done in the Design Builder. This software can define all the parameter needed.

FIGURE 3.8: Energy Plus

3.6 Simulation Step

3.6.1 First Step - Design a House

FIGURE 3.9: Single Story house

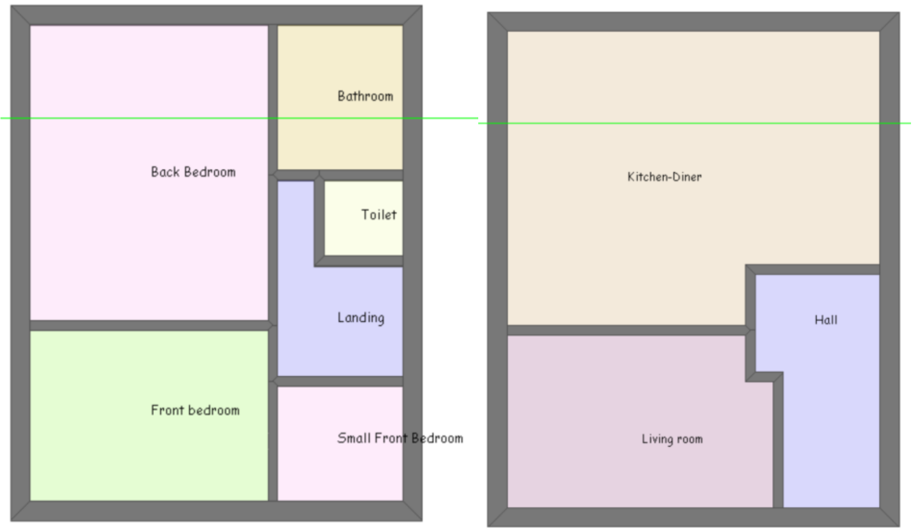

FIGURE 3.10: Plan layout for the house

3.6.2 Second Step – Define the activity

Activity in each room was define to provide the space occupancy data. Each space has different activity been carried out.

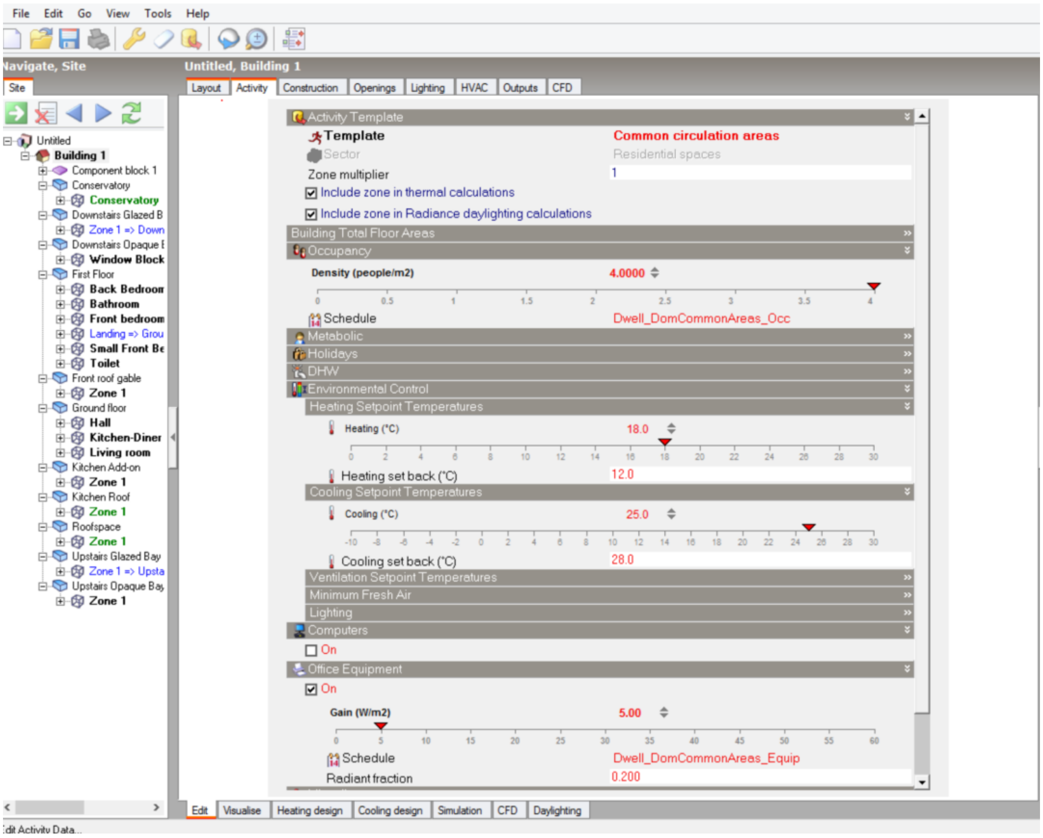

FIGURE 3.11: Define the activity

3.6.3 Third Step – Define the construction

Different construction type has been set for the simulation purpose.

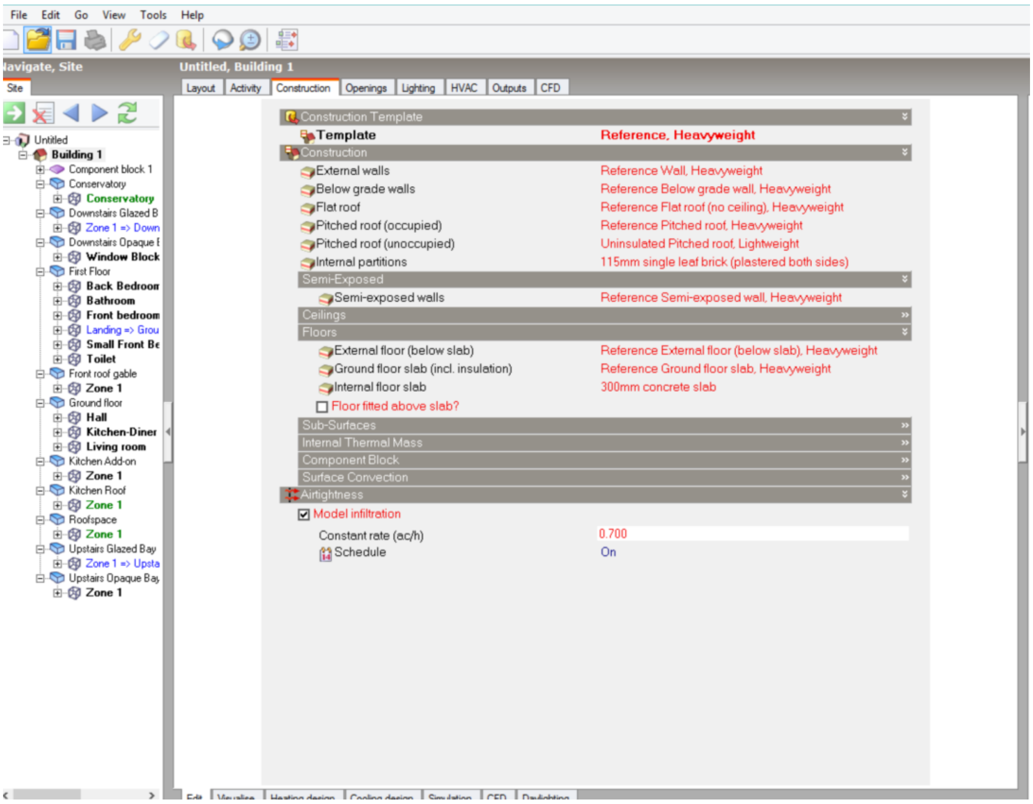

FIGURE 3.12: Define the construction

3.6.4 Fourth Step – Define the HVAC system

HVAC system was define to provide the data during the simulation.

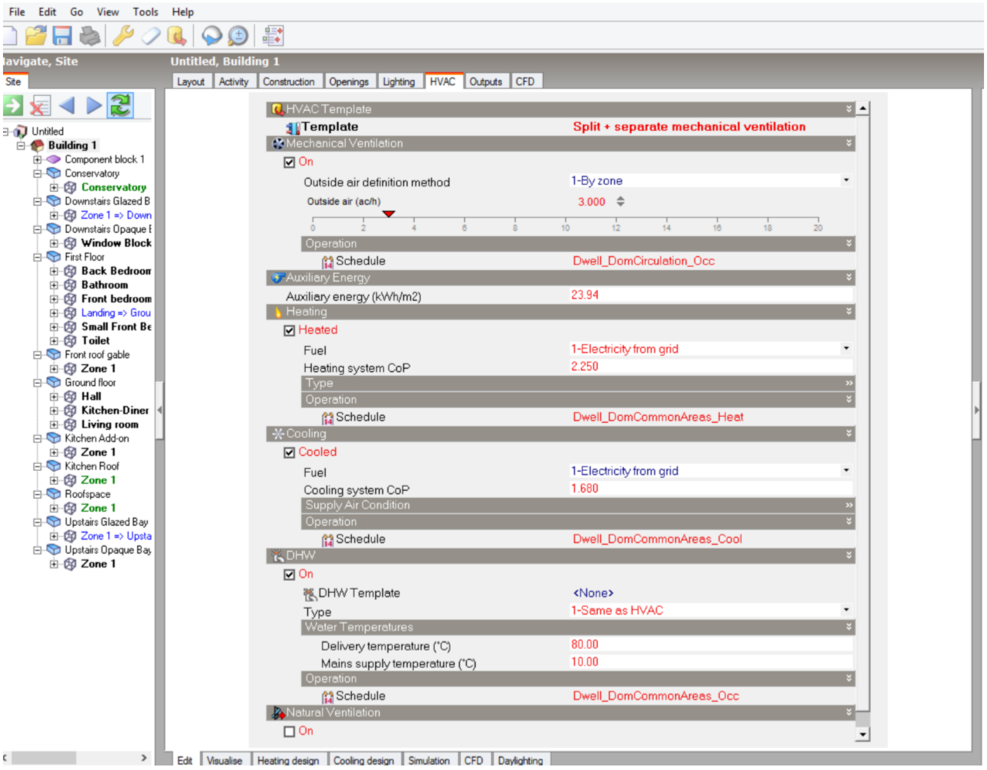

FIGURE 3.13: Define the HVAC system

3.6.5 Fifth Step – Set the needed Output Data

Output data can be selected according to simulation purpose.

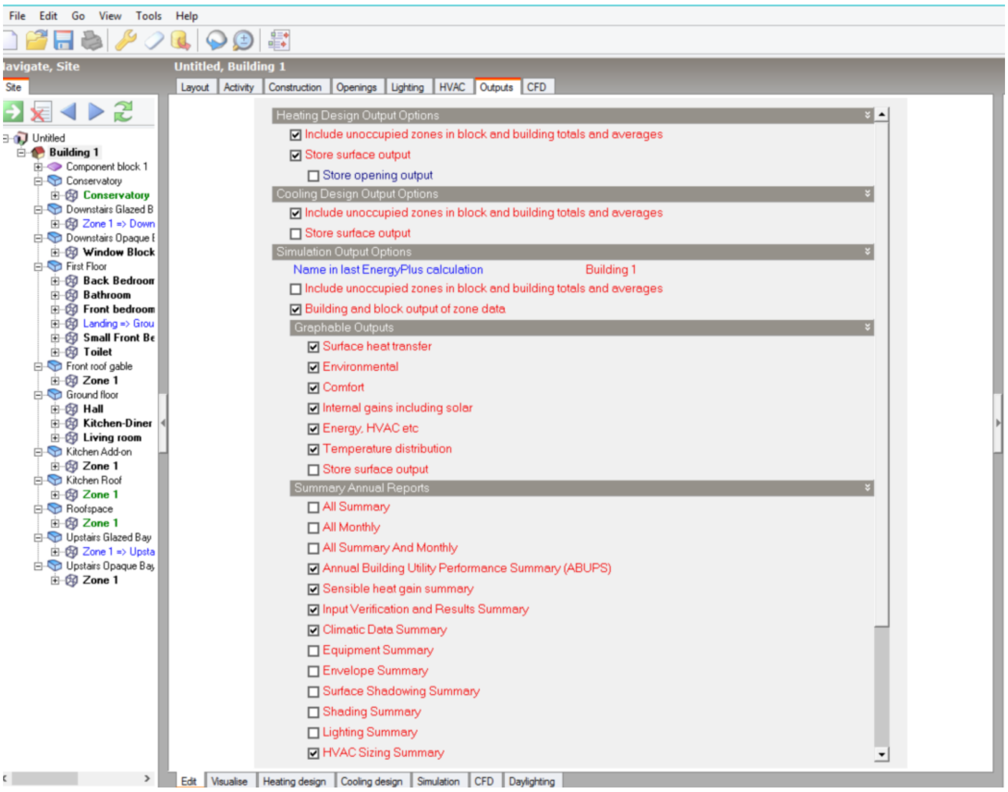

FIGURE 3.14: Output Data

3.6.6 Sixth Step – Run the simulation

After complete insert the detail, simulation can be done. It take about 15 minutes depends on the output and if there is no error during insert the data.

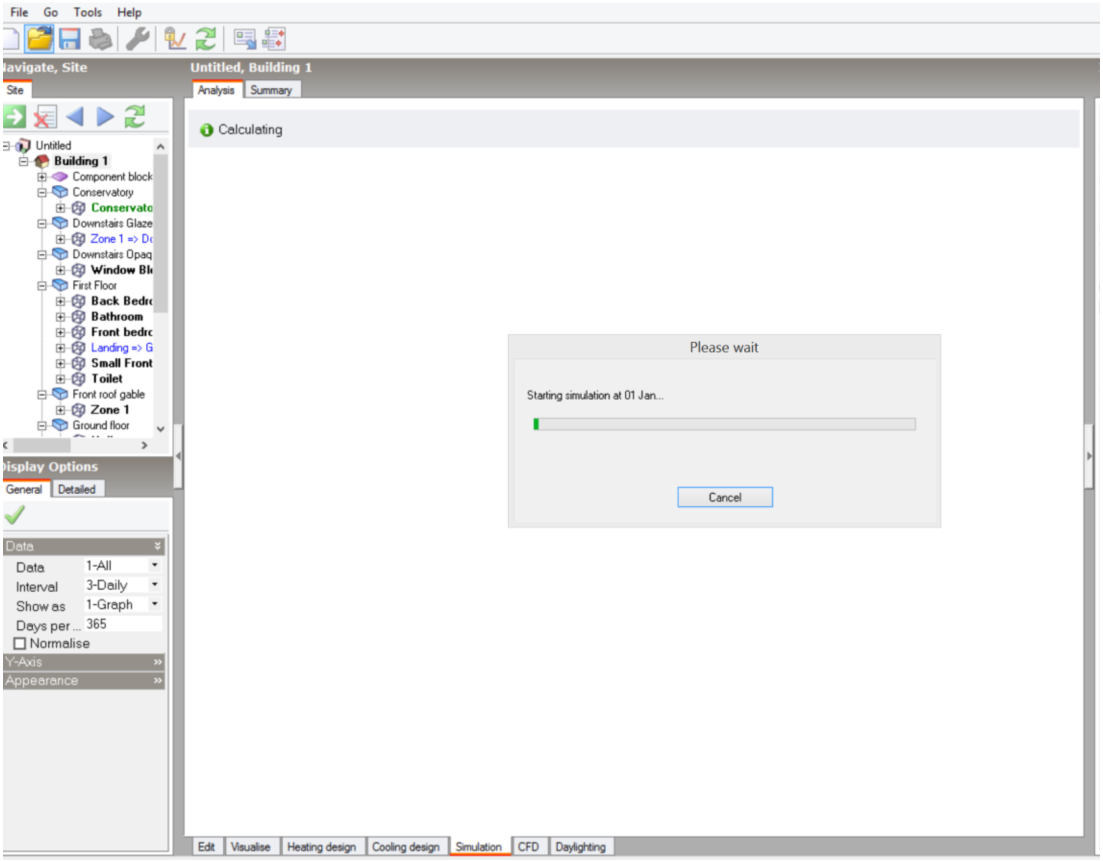

Figure 3.15: Simulation

3.6.7 Last Step – View and analyse the result

The final result will come out and analysis can be done according to purpose of study.

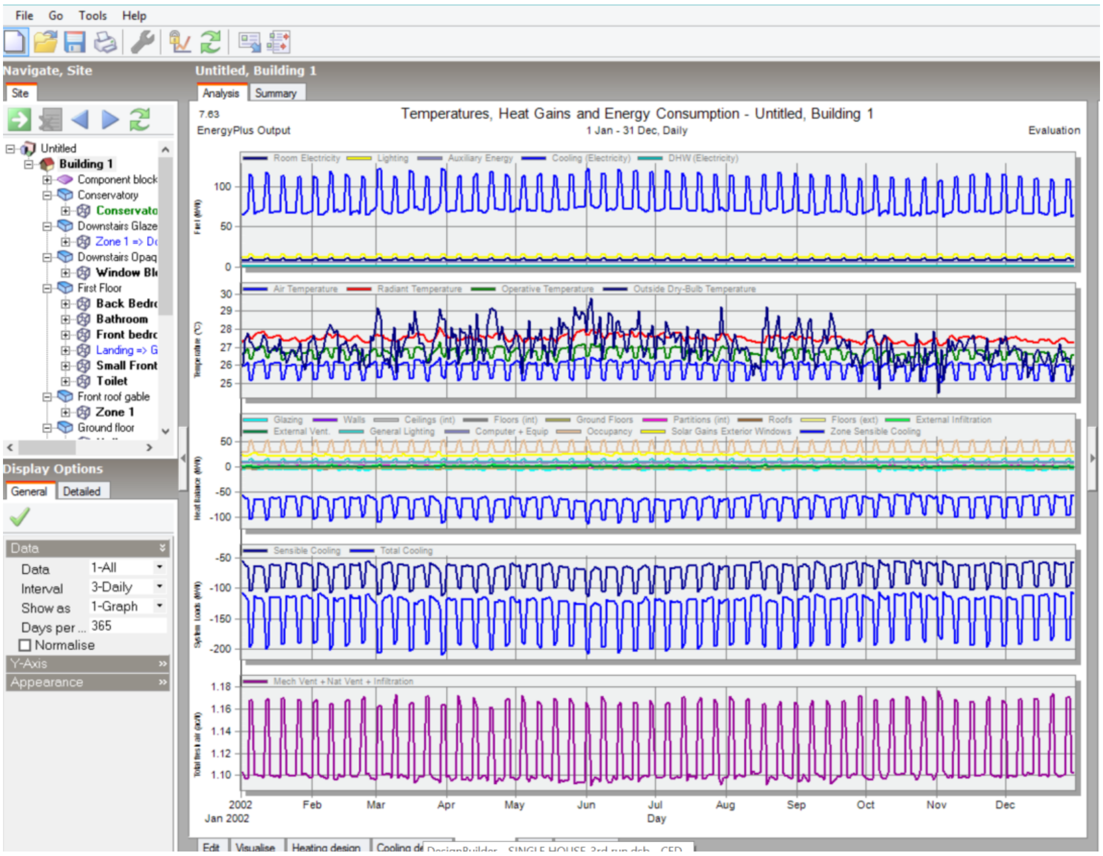

FIGURE 3.16: Summary of the simulation

CHAPTER 4

RESULT AND DISCUSSION

This chapter present and discusses the simulation on energy consumption in residential house by using Energy Plus and Design Builder software. The analysis will be focused on effect of different roof type and the weather change to energy consumption in residential house. At the end of the discussion, analyse will be done on the production of carbon dioxide in residential house.

For this project, there are two selected location which are Kuala Lumpur and Bangkok. The purpose of selecting two different location because each location have different type of weather. Basically this simulation focused on normal roof and insulation roof. The double story house has similar structure and dimension except the flat roof layer

The type of insulation material for the roof as per below:

1. Acrylic with U-Value ranging 0.10 W/m^2K to 0.5 W/m^2K
2. Asphalt with U-Value ranging 0.10 W/m^2K to 0.5 W/m^2K
3. Grass/straw with U-Value ranging 0.10 W/m^2K to 0.5 W/m^2K
4. Standard insulation with U-Value ranging 0.10 W/m^2K to 0.5 W/m^2K
5. Reflective coat with U-Value ranging 0.10 W/m^2K to 0.5 W/m^2K

The thickness for the insulator is constant. The flat roof design have 4 layer as per below:

Outermost layer (Insulation layer)
Layer 2 (Foam Polyisocyanate)
Layer 3 (200 mm air gap > = 25mm
Innermost layer (13.00 mm Plasterboard)

4 ANALYSIS ON RESIDENTIAL HOUSE

4.1 Description of the house

The area of the house is the same for both in Kuala Lumpur and Bangkok. Table 4.1 below shows the total area for the house.

TABLE 4.1: Total Area of the building

	Area [m2]
Total Building Area	145.57
Net Conditioned Building Area	89.97
Unconditioned Building Area	55.61

TABLE 4.2: Surface by class of the building

	Total	**Outdoors**
Wall	136	79
Floor	40	17
Roof	34	11
Internal Mass	0	0
Building Detached Shading	10	10
Fixed Detached Shading	0	0
Window	31	31
Door	13	1
Glass Door	0	0
Shading	0	0
Overhang	0	0
Fin	0	0
Tubular Daylighting Device Dome	0	0
Tubular Daylighting Device Diffuser	0	0

4.2 Report on Annual Building Utility Performance Summary in Kuala Lumpur

TABLE 4.3 : Site and source energy for the building in Kuala Lumpur

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	56894.31	390.83	632.39
Net Site Energy	56894.31	390.83	632.39
Total Source Energy	78166.63	536.96	868.83
Net Source Energy	78166.63	536.96	868.83

4.3 Report on Annual Building Utility Performance Summary in Bangkok

TABLE 4.4: Site and source energy for the building in Bangkok

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	40716.01	279.69	452.57
Net Site Energy	40716.01	279.69	452.57
Total Source Energy	60517.96	415.72	672.67
Net Source Energy	60517.96	415.72	672.67

Table above show the total energy consumption by the residential house in Kuala Lumpur and Bangkok. It is shows that a house in Kuala Lumpur consume more energy compare to Bangkok. Due to different weather, the energy consumption will be different even though the house have same space and area.

Residential house in Kuala Lumpur consume 22.28% more energy compare to Bangkok. The factor that affect the energy consumption of a house is the construction industry in that particular location.

4.4 Roof without insulator

TABLE 4.5 : Heat balance for insulated roof

	Uninsulated
January	19.59
February	20.955
March	31.035
April	22.26
May	16.455
June	26.19
July	17.94
August	22.95
September	24.135
October	17.01
November	15.48
December	11.37

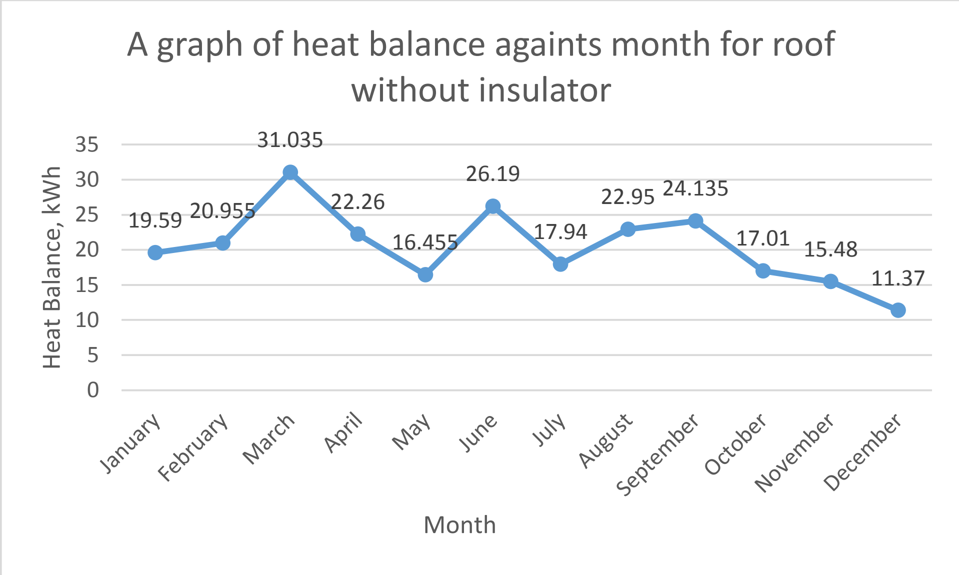

FIGURE 4.1: A graph of heat balance vs month for roof without insulator

Figure below shows the heat balance for the residential house without an insulator. Heat balance for uninsulated roof is much higher compare to a house with an insulator roof. Uninsulated roof consume about 21.24% more heat compare to a roof with insulator.

4.5 Roof with insulator

4.5.1 Thermal transmittance, U = 0.10

Table 4.6 : Heat balance for different type of roof insulator when U-Value 0.10

	Reflective coat	Grass/straw	Standard insulation	Acrylic	Asphalt
January	13.67	14.32	14.37	14.37	14.44
February	14.71	15.27	15.31	15.3	15.36
March	22.12	22.83	22.87	22.87	22.92
April	16.83	17.68	17.71	17.71	17.75
May	13.77	14.89	14.91	14.91	14.94
June	20.98	22.15	22.17	22.19	22.21
July	15.06	16.24	16.26	16.27	16.29
August	17.58	18.54	18.56	18.57	18.6
September	17.57	18.28	18.31	18.31	18.36
October	12.08	12.74	12.78	12.78	12.83
November	10.6	11.14	11.19	11.19	11.25
December	7.66	8.16	8.21	8.21	8.27

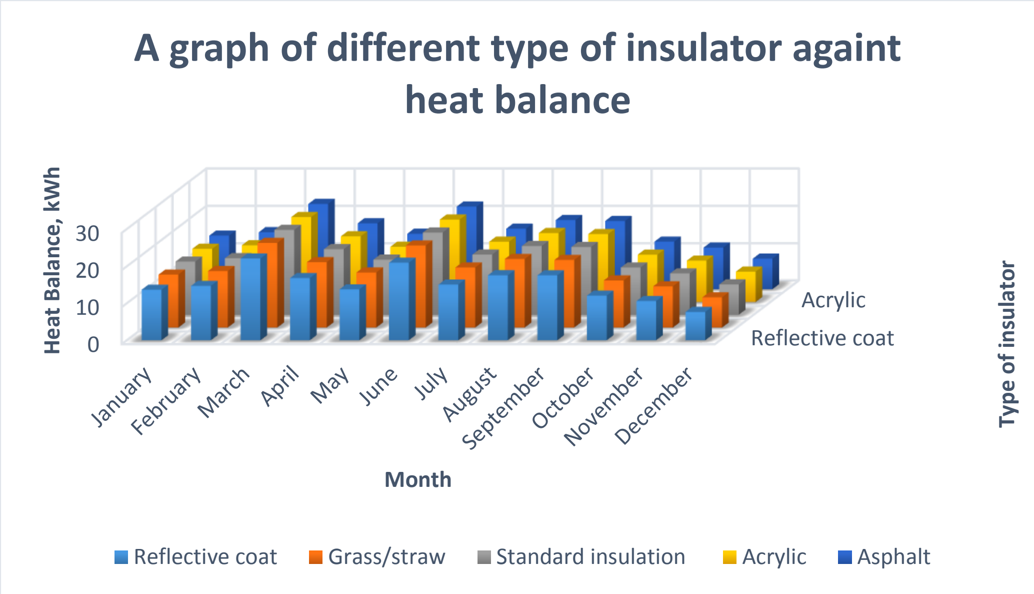

FIGURE 4.2: A graph of different type of insulator vs heat balance

4.5.2 Thermal transmittance, U = 0.20

TABLE 4.7: Heat balance for different type of roof insulator when U-Value 0.20

	Reflective	Grass/straw	Acrylic	Standard insulation	Asphalt
January	14.08	14.1	14.19	14.2	14.33
February	15.06	15.08	15.15	15.16	15.26
March	22.57	22.58	22.65	22.66	22.75
April	17.38	17.39	17.43	17.44	17.5
May	14.49	14.5	14.53	14.54	14.58
June	21.75	21.72	21.79	21.75	21.82
July	15.84	15.81	15.87	15.84	15.91
August	18.2	18.18	18.25	18.23	18.3
September	28.03	18.03	18.09	18.09	18.17
October	12.51	12.5	12.58	12.58	12.68
November	10.95	10.95	11.04	11.03	11.15
December	7.98	7.99	8.07	8.08	8.2

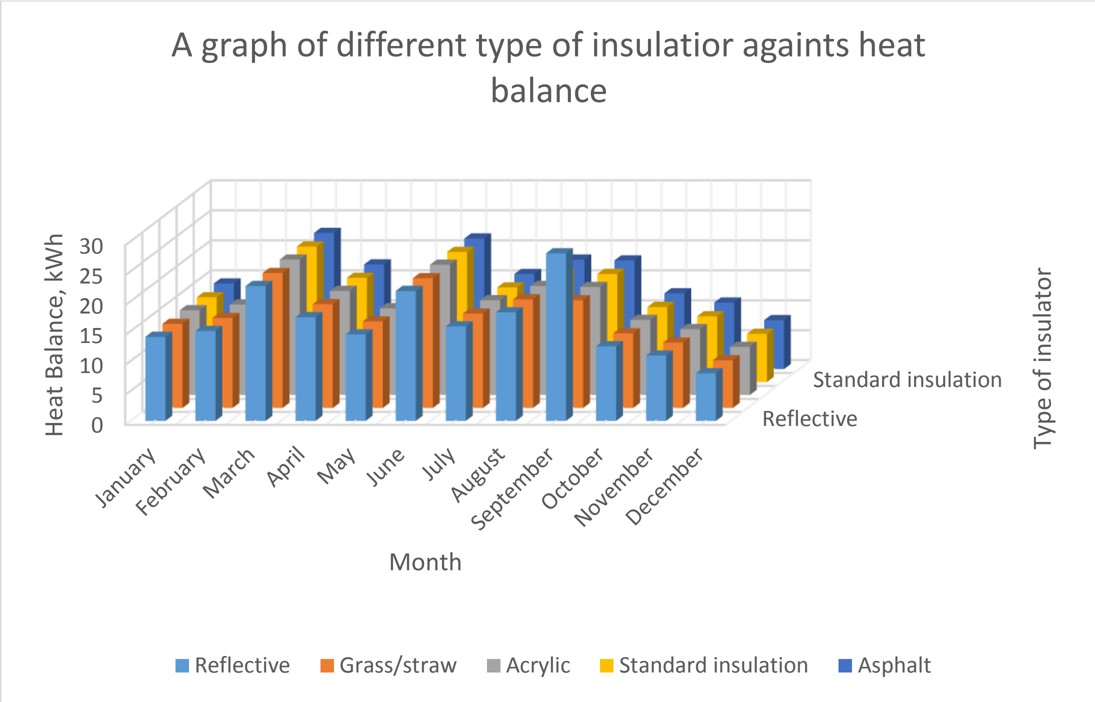

FIGURE 4.3: A graph of different type of insulator vs heat balance

4.5.3 Thermal transmittance, U = 0.30

TABLE 4.8 : Heat balance for different type of roof insulator when U-Value 0.30

	Reflective	Grass/straw	Acrylic	Standard insulation	Asphalt
January	13.87	13.9	14.02	14.04	14.22
February	14.88	14.91	15	15.02	15.16
March	22.34	22.36	22.45	22.46	22.59
April	17.1	17.11	17.17	17.19	17.28
May	14.12	14.13	14.18	14.18	14.24
June	21.36	21.31	21.41	21.36	21.45
July	15.44	15.4	15.49	15.45	15.54
August	17.88	17.85	17.95	17.91	18.02
September	17.79	17.8	17.88	17.88	18
October	12.29	12.29	12.4	12.39	12.53
November	10.77	10.77	10.9	10.9	11.06
December	7.81	7.83	7.94	7.97	8.13

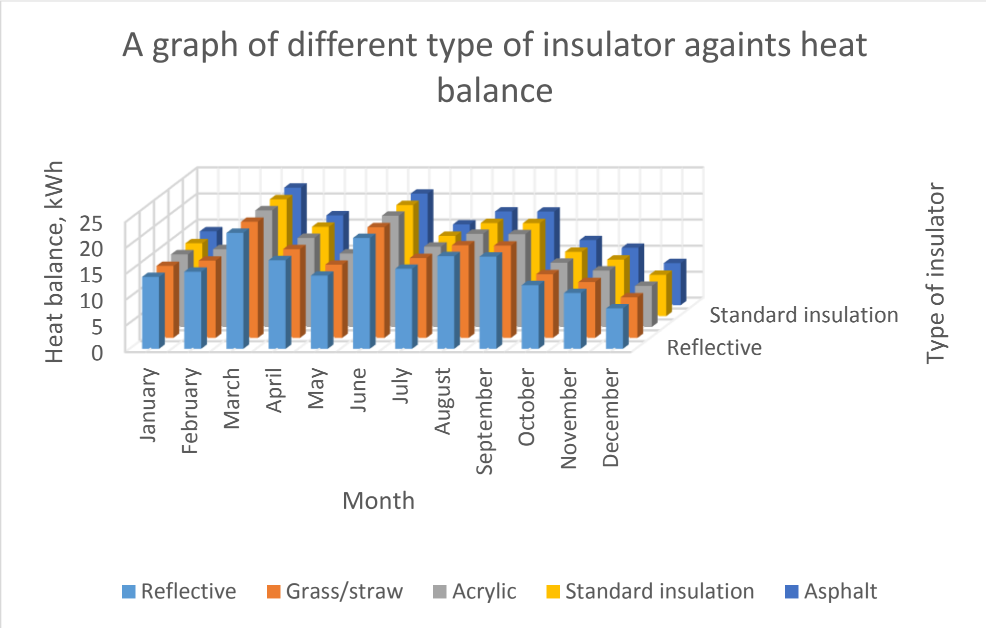

FIGURE 4.4: A graph of different type of insulator vs heat balance

4.5.4 Thermal transmittance, U = 0.40

TABLE 4.9 : Heat balance for different type of roof insulator when U-Value 0.40

	Reflective Coat	Grass	Acrylic	Standard insulation	Asphalt
January	13.67	13.71	13.86	13.9	14.13
February	14.71	14.75	14.86	14.89	15.07
March	22.12	22.15	22.26	22.28	22.44
April	16.83	16.86	16.93	16.95	17.06
May	13.77	13.79	13.84	13.85	13.93
June	20.98	20.93	21.05	20.99	21.11
July	15.06	15.02	15.13	15.08	15.19
August	17.58	17.54	17.66	17.62	17.76
September	17.57	17.58	17.68	17.69	17.83
October	12.08	12.08	12.22	12.22	12.4
November	10.6	10.61	10.77	10.77	10.99
December	7.66	7.68	7.83	7.84	8.07

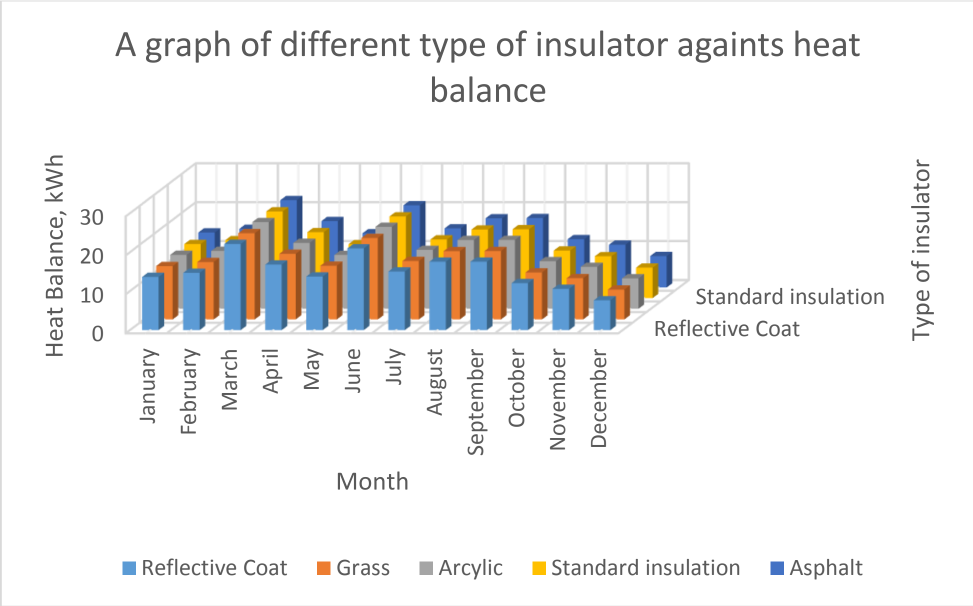

FIGURE 4.5: A graph of different type of insulator vs heat balance

4.5.5 Thermal transmittance, U = 0.50

TABLE 4.10 : Heat balance for different type of roof insulator when U-Value 0.10

	Reflective	Grass	Acrylic	Standard insulation	Asphalt
January	13.48	13.54	13.72	13.76	14.04
February	14.55	14.59	14.73	14.77	14.99
March	21.92	21.95	22.08	22.11	22.31
April	16.58	16.61	16.7	16.72	16.86
May	13.44	13.46	13.52	13.53	13.62
June	20.64	20.57	20.71	20.64	20.78
July	14.71	14.66	14.79	14.73	14.86
August	17.29	17.25	17.39	17.34	17.51
September	17.36	17.37	17.49	17.5	17.68
October	11.89	11.89	12.06	12.05	12.27
November	10.45	10.46	10.66	10.65	10.91
December	7.51	7.53	7.71	7.74	8.01

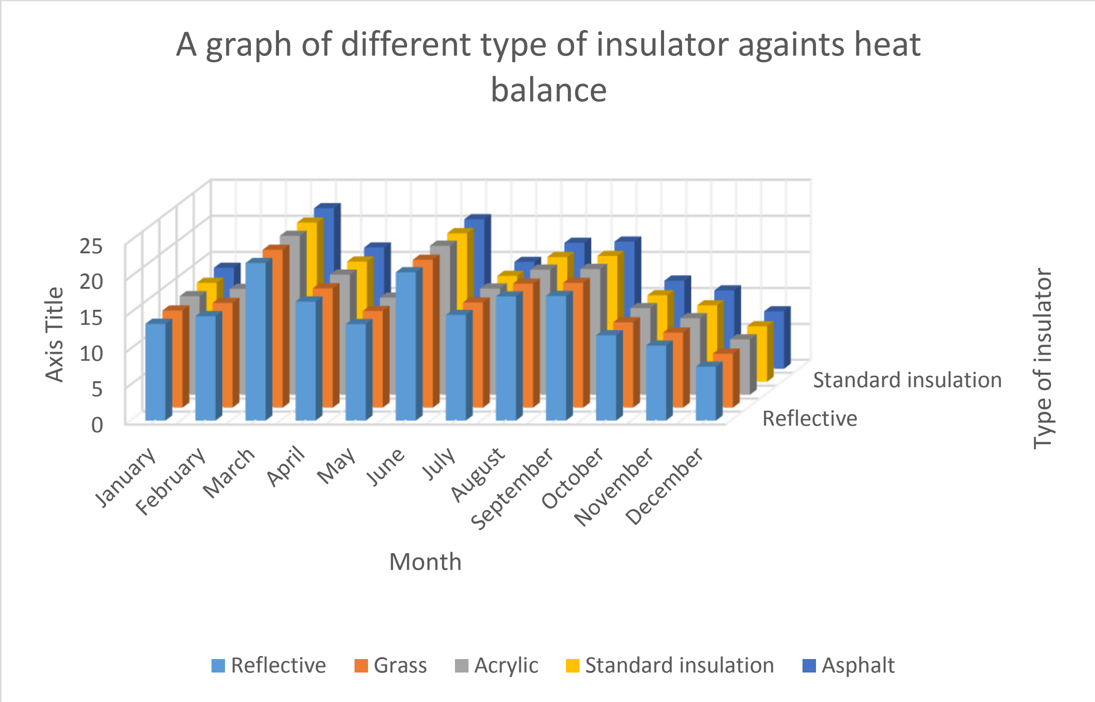

FIGURE 4.6: A graph of different type of insulator vs heat balance

The figure and table above shows that the heat balance with different type of insulator. It shows that reflective coat material has a good heat balance among all 5 type of insulator material. The reflective coat insulator slow down the heat transfer from the roof to the residential house. Less heat gain from the roof to the residential house. Thus the house keep comfort and it can reduce the energy consumption and less carbon dioxide is emitted.

Besides that, when the U-Value increase, the heat balance will increase. U-Value is the rate of heat transfer through the structure.

4.6 Production of Carbon dioxide in Kuala Lumpur and Bangkok

TABLE 4.11: Emission of CO_2 by residential house

Month	Kuala Lumpur	Bangkok
	Carbon Dioxide, kg	
January	2231.96	1584.99
February	2051.08	1514.07
March	2347.46	1802.81
April	2199.42	1776.38
May	2267.77	1787.55
June	2333.08	1800.9
July	2274.91	1707.54
August	2279.9	1660.04
September	2193.35	1634.73
October	2185.96	1683.84
November	2191.96	1614.01
December	2220.38	1520.93

TABLE 4.12: Production of CO_2 (tonnes) per capita

Location	Kuala Lumpur	Bangkok
Total carbon dioxide	26777.23 kg	20087.79 kg
Carbon dioxide emission (tonnes) per capita	8.92	6.70

The production of carbon dioxide in Kuala Lumpur is higher than Bangkok. The pattern is increase when compare to the existing data in energy website. In Malaysia, 7.8 metric tonne per capital in 2011 where as in Thailand, 4.6 metric tonne per capital in 2011. It shows that, it has increase about 12.56% in Malaysia and 31.34% in Bangkok. The rapid growth of construction industry tend to increase the emission of carbon dioxide.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Based on the simulation been done, it shows that different roof type has different heat transfer from the roof to the house building. Reflective coat material is a good insulator compared to other 4 material. It reduce the heat transfer from roof to residential house.

Energy consumption in a building depends on the weather condition at that place. Based on this simulation, even though the house has same area but the energy consumption was different in between Kuala Lumpur and Bangkok. It shows that the weather give the impact to the energy consumption in the residential house.

Apart from that, the production of carbon dioxide by residential house also increase form years to years. Carbon dioxide emission from the residential house is one of the major cause to the global warming. The construction growth and economic growth of a country will reflect the production of carbon dioxide.

In order to improve the analysis, the simulation can be done by changing the thickness of insulator material to see the effect to heat balance of the residential house. Other than that, an experimental model also can be done to compare the experimental study with the simulation analysis.

An analysis also can be run with other software to make a comparison the performance of the roof. Besides that, the existing residential house can be one part of the roof study. Monthly basis monitoring study can be done to study the energy consumption and roof performance. Monitoring can be done with different type of house such as single house, terrace, apartment and semi-D house.

In a conclusion, further research should be done to study and analyse the roof performance and cost analysis should be consider to choose the best type of roof material with a better energy saving to reduce the emission of carbon dioxide.

REFERENCES

A.H. Rosenfeld, H. Akbari, S. Bretz, B.L. Fishman, D.M. Kurn, D. Sailor, H. Taha, Mitigation of urban heat islands: material, utility programs, updates, Energy and Buildings 22 (3) (1995) 255-265.

Al Yacouby, A., Khamidi, M.F., Nuruddin, M.F., Idrus, A., Farhan, S.A., Razali A.E., 2011. A Review on thermal performance of roofing materials in Malaysia. In: Proceedings of the International Building and Infrastructure Technology. Penang, Malaysia

Allen, L.K.K., Elias S., Lim, C.H., 2008. The thermal performance of evaluation of roofing systems and materials in Malaysian residential development. In: Proceedings of SENVAR, ISESEE, Humanity and Technology. pp. 387–395

B. Givoni. Man, Climate and Architecture, Applied Science Publishers, 1967.

Chan, S.A., 2004. Energy efficiency: designing low energy buildings using energy 10. In: Proceedings of the 7th CPD Seminar, Pertubuhan Arkitek Malaysia, Kuala Lumpur, Malaysia, 1–18.

D.S. Parker, S.F. Barkaszi Jr., Roof solar reflectance and cooling energy use: field research result from Florida, Energy and Building 25 (2) (1997) 105-115.

E. Hertwich, G. Peters, Carbon footprint of nations; a global, trade-linked analysis, Environmental Science and Technology 43 (2009) 6414-6420.

Energy Commission, 2010. Interim Report on the Performance of the Electricity Supply Services in Malaysia (for first half year of 2010), Energy Commission, Putrajaya, Malaysia.

Fridley DG, Zheng, N, and Zhou, N, Estimating total energy consumption and emissions of China’s commercial and office buildings, Division, E.E.T., editor. 2008, Lewrence Berkeley National Laboratory.

Giannakopoulos C, Psiloglou BE. Trends in energy load demand for Athens Greece: weather and non-weather related factors. Climate Research 2004(31): 97-108.

Humphreys M. Outdoor temperature and comfort indoors. Batim International Build Research and Practice 1978:6(2):92-105.

IEA, World Energy Outlook, 2008 Edition, International Energy Agency, Paris France,2008.

International Energy Agency, 2009. Electricity/Heat Data for Malaysia [Online]. Available from World Wide Web: ⟨http://www.iea.org/ stats/electricitydata.asp?COUNTRY_CODE=MY⟩ (accessed 03.06.14)

IPCC, Climate change 2007: the physical science basis. Contribution of working group 1 to the fourth assessment Report of the intergovernmental panel on climate change, in Cambridge University Press, Solomon S. D.Q, M Manning, Z Chen, M Marquis, KB Avenryt, M Tignor, HL Miller, edition. 2007: Cambridge, United Kingdom and New York, USA.

J. Heinomen, The Impacts of Urban Structure and the Related Consumption Patterns on the Carbon Emissions of an Average Consumer (Ph.D. Thesis), Aalto University, Heisinki, Finaland, 2007.

J. Yu, C. Yang, L. Tian, Low-energy envelope design of residential building in hot summer and cold winter zone in China, Energy and Buildings 40 (2008) 1536-1546.

Kwok AG, Rajkovich NB. Addressing climate change in comfort standards. Building and Environment 2010;45(1):18-22.

N.M. Nahar, P. Chand, Passive cooling technique in buildings: past and present a review, ARISER 4 (2008) 37-46.

P. Houvila, M. Ala-Juiseia, L. Meichert, S. Pouffary, Building and Climate Change Status, Challenges and Opportunities, United Nations Environment Programme, Paris, France,2007.

Saidur, R., Masjuki, H.H., Jamaluddin, M.Y., Ahmed, A., 2007.cEnergy and associate greenhouse gas emissions from household appliances in Malaysia. Energy Policy 35, 1648–1657.

T. Feng, Y. Jun, Influence of retro-reflective material on public buildings energy consumption on different climate regions, Journal of Chemical and Pharmaceutical Research 5 (2013) 447-452.

Urban, B., Roth, K., 2010. Guidelines for Selecting Cool Roofs, U.S. Department of Energy Building Technologies Program and Oak Ridge National Laboratory. <www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf> (accesses 10.01.14).

U. Eiker, Low Energy Cooling for Sustainable Buildings, 1 st ed., John Wiley & Son, 2009.

Vijaykumar, K.C.K., Srinivasan, P.S.S., Dhandapani, S., 2007. A performance of hollow tiles clay (HTC) laid reinforced cement concrete (RCC) roof for tropical summer climates. Energy Build.39, 886–892.

APPENDICES

DESCRIPTION OF THE ROOF BASED ON INSULATOR MATERIAL

APPENDIX A: Asphalt

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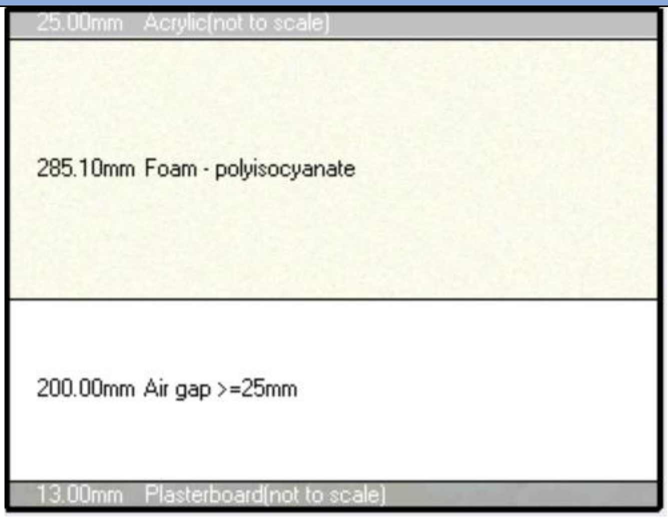
<tr><td>0.10</td><td>
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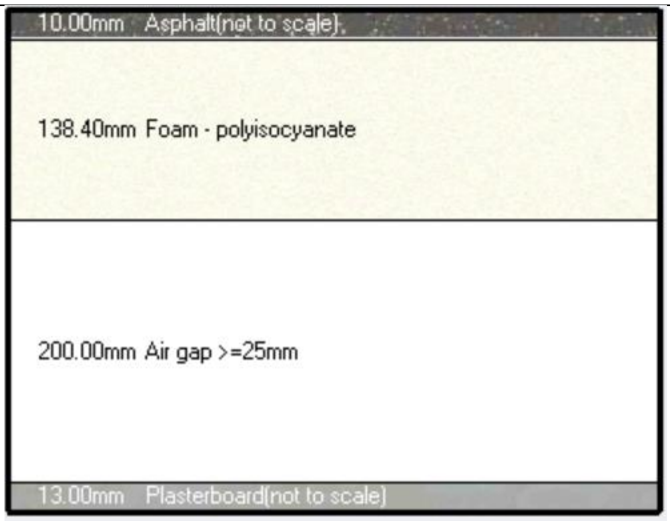
<tr><td>0.20</td><td>
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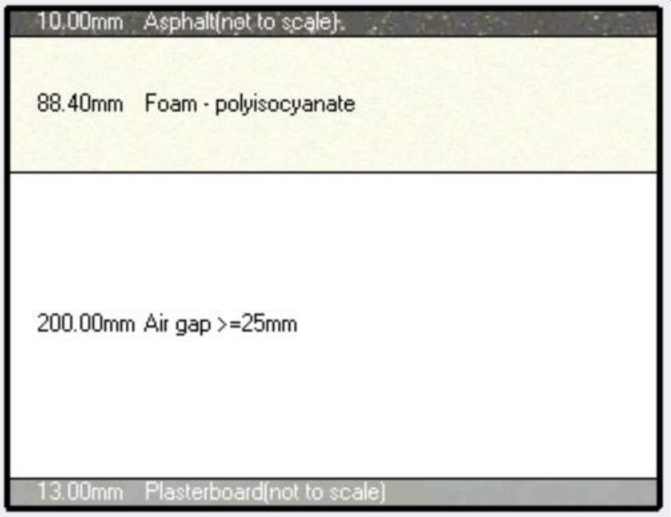
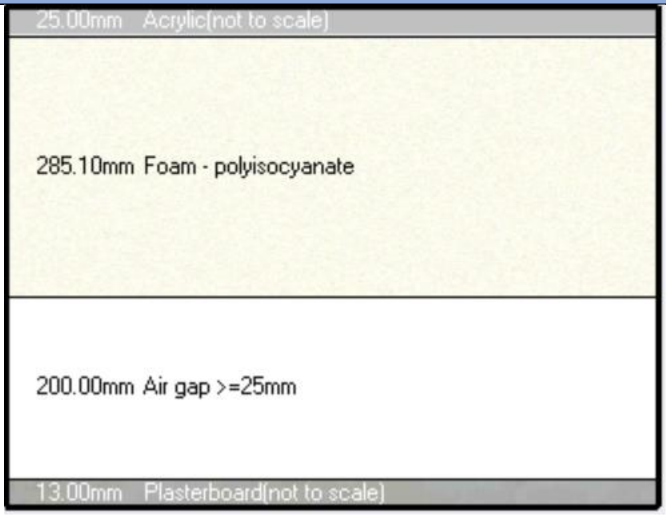
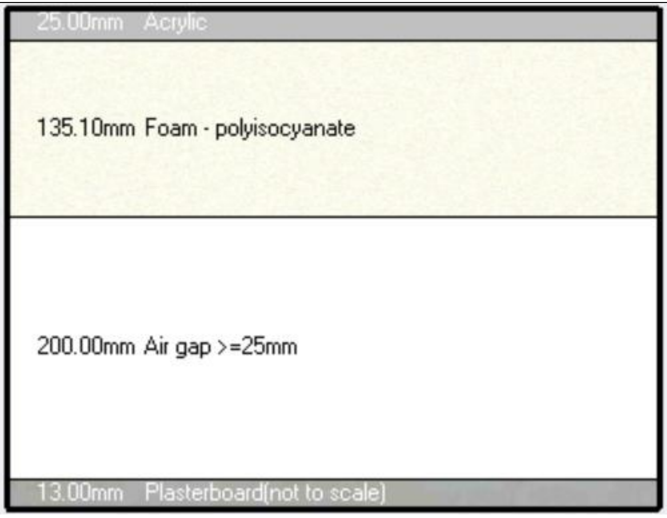
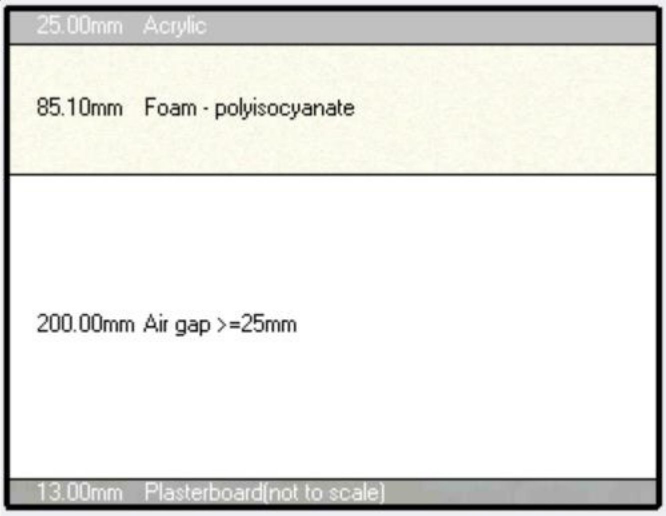
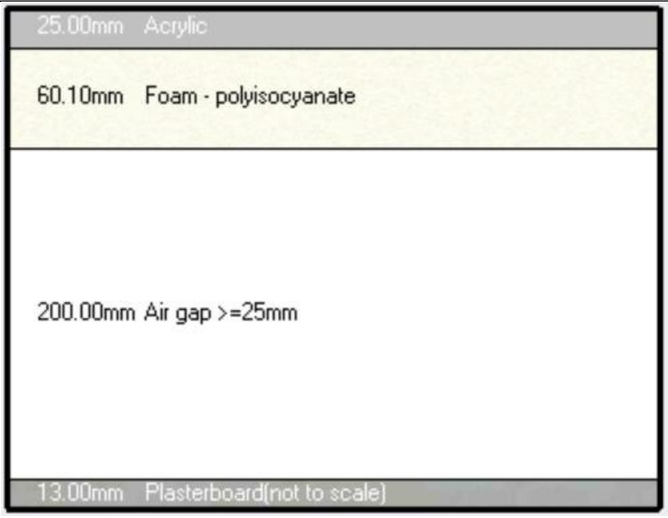
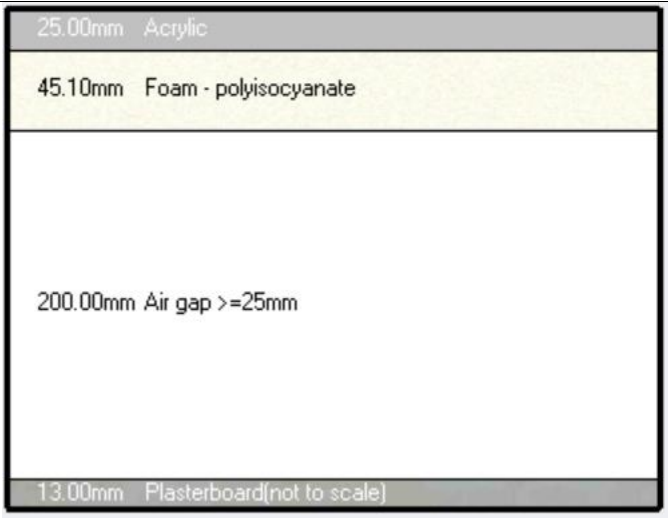
0.30	10.00mm Asphalt(not to scale) 88.40mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)
0.40	10.00mm Asphalt(not to scale) 63.40mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)
0.50	10.00mm Asphalt(not to scale) 88.40mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)

APPENDIX B: Acrylic

U-Value, W/m^2 - k	Insulator layer
0.10	
0.20	
0.30	

0.40	25.00mm Acrylic 60.10mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)
0.50	25.00mm Acrylic 45.10mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)

APPENDIX C: Grass/Straw

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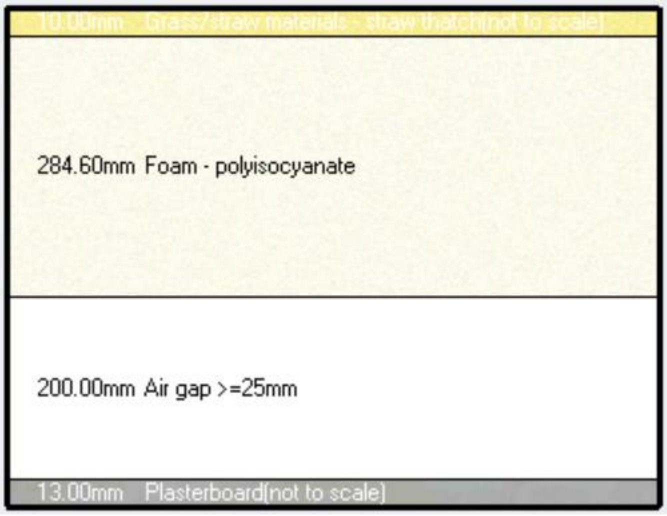
<tr><td>0.10</td><td>
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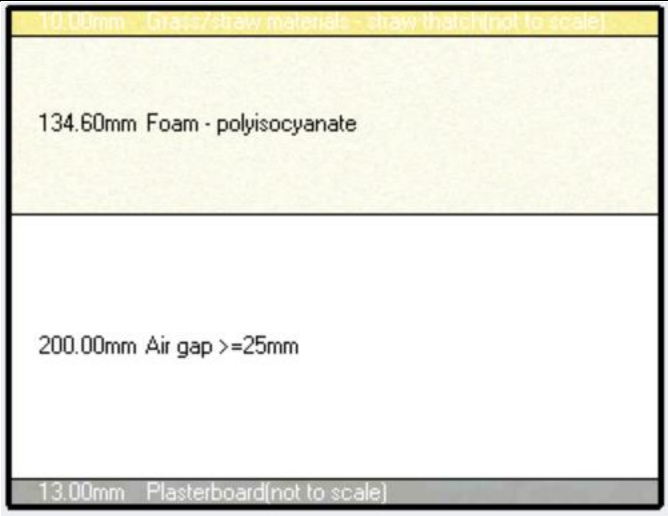
<tr><td>0.20</td><td>
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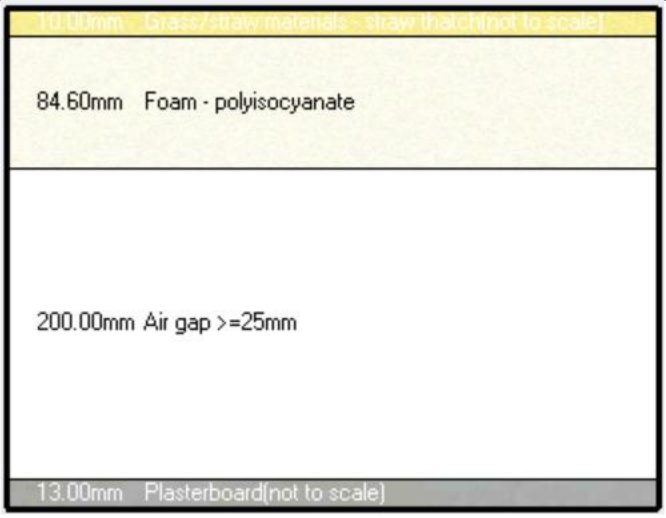
<tr><td>0.30</td><td>
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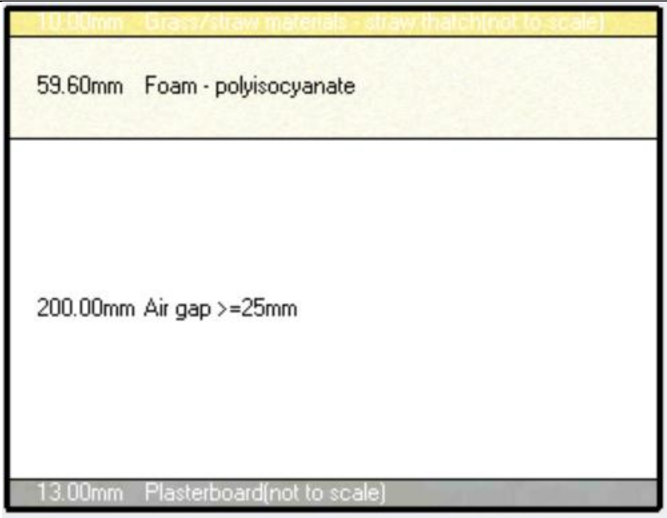
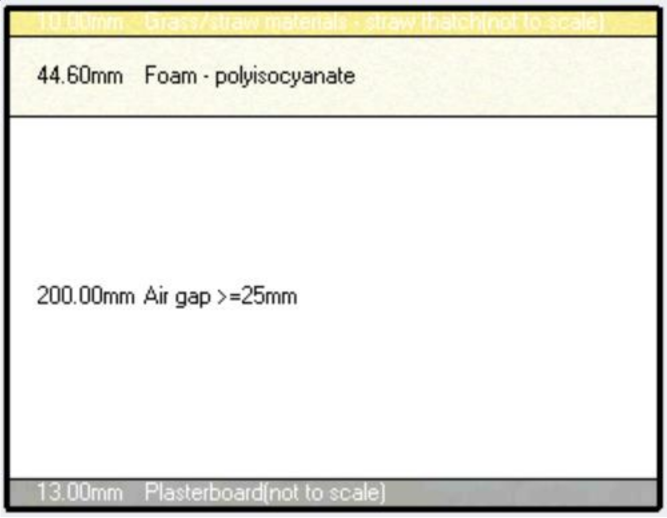
0.40	 10.00mm Grass/straw materials - straw thatch(not to scale) 59.60mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)
0.50	 10.00mm Grass/straw materials - straw thatch(not to scale) 44.60mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)

APPENDIX D: Standard Insulation

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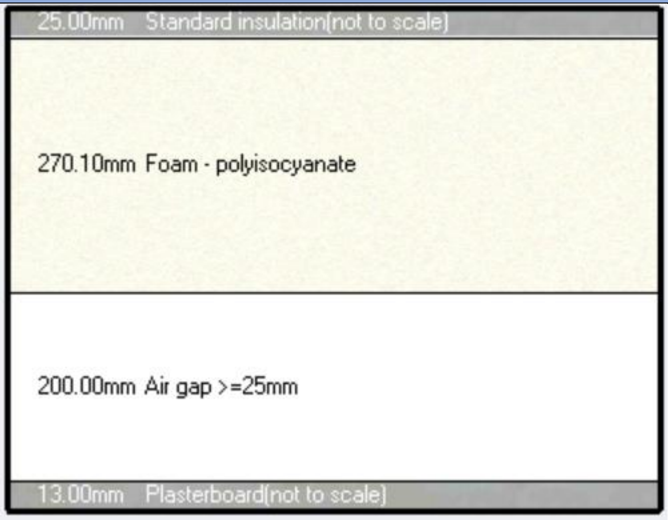
<tr><td>0.10</td><td>
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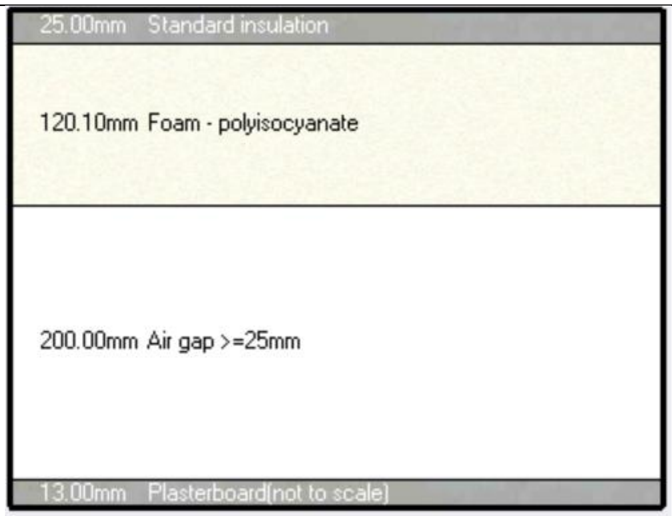
<tr><td>0.20</td><td>
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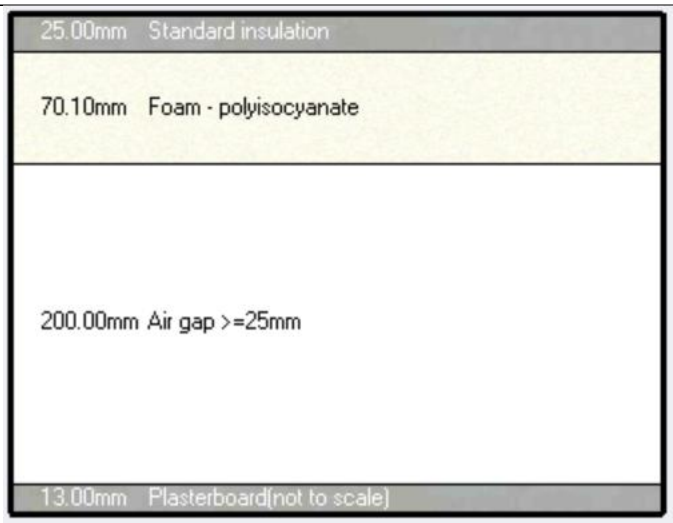
<tr><td>0.30</td><td>
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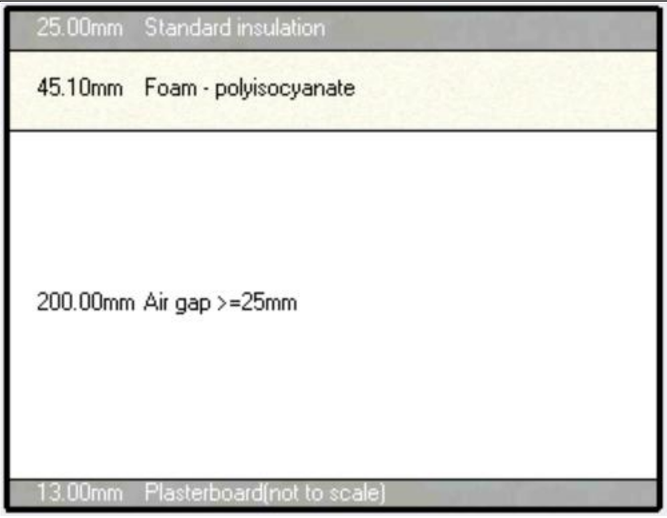
<tr><td>0.40</td><td>
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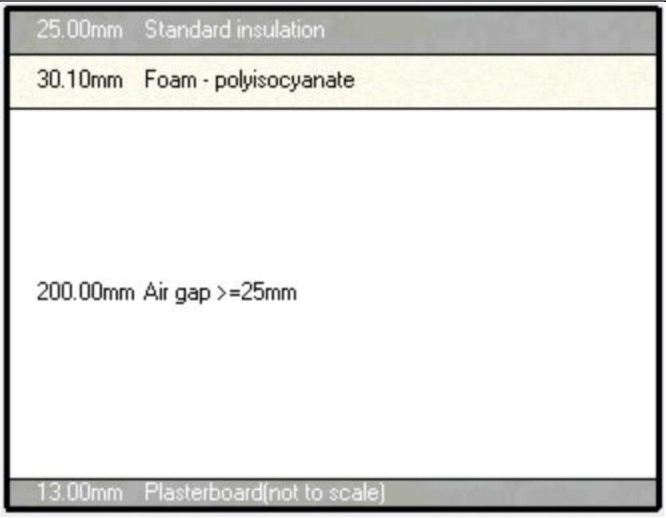
<tr><td>0.50</td><td>
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APPENDIX E: Reflective Coat

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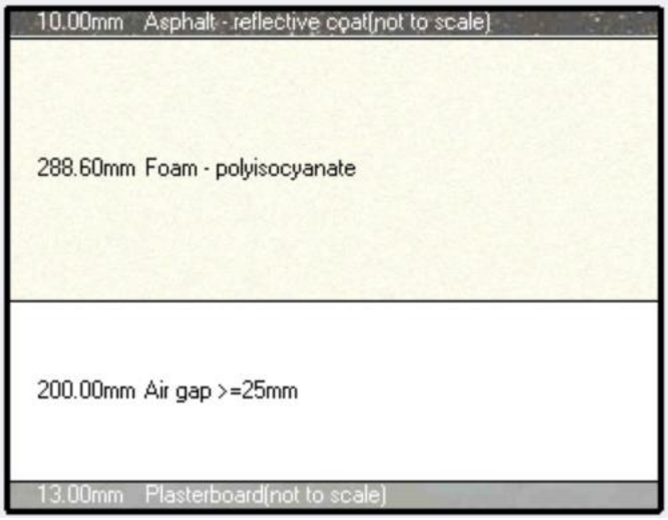
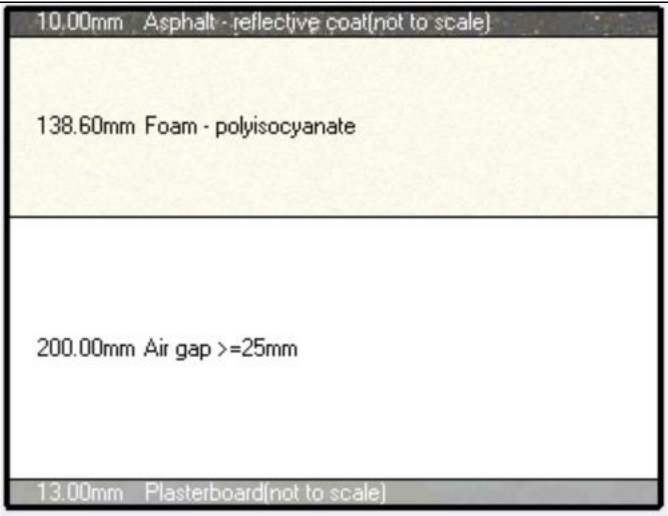
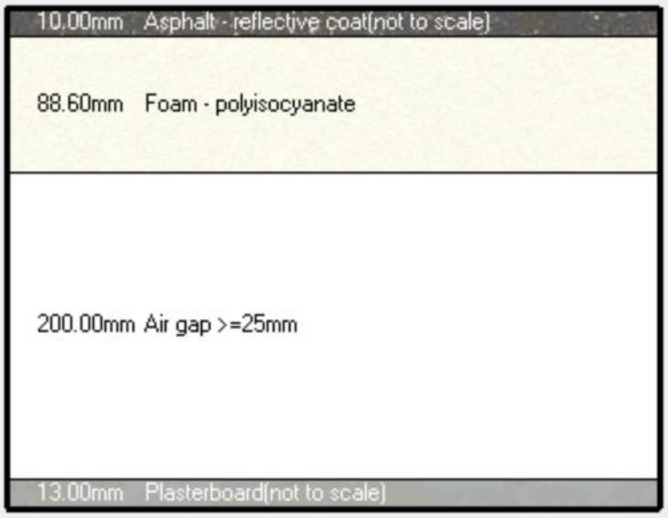
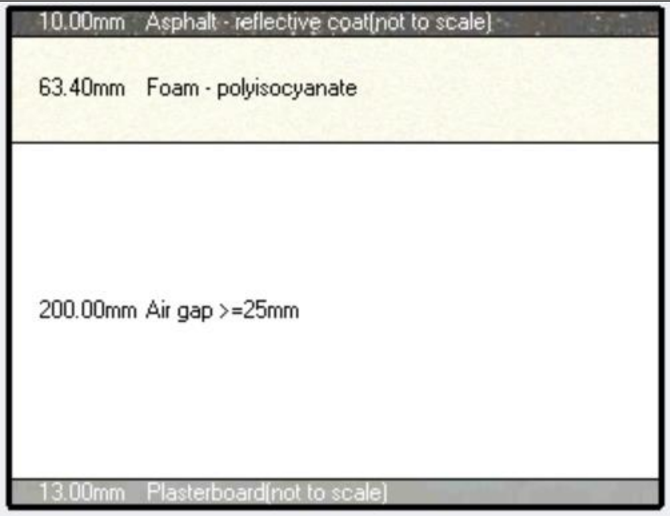
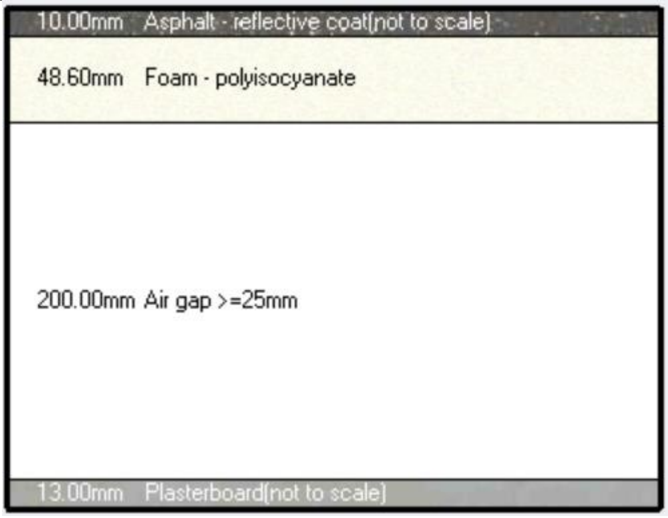
0.10	
0.20	
0.30	

0.40	10.00mm Asphalt - reflective coat(not to scale) 63.40mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)
0.50	10.00mm Asphalt - reflective coat(not to scale) 48.60mm Foam - polyisocyanate 200.00mm Air gap >=25mm 13.00mm Plasterboard(not to scale)